

VARIABLE STARS IN THE GLOBULAR CLUSTER M14

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ABSTRACT

Using an image subtraction method we have searched for variable stars in the globular cluster M14. We confirmed 62 previously known variables catalogued by Wehlau & Froelich (1994). In addition to the previously known variables we have identified 71 new variables. We have confirmed the periods of most of Wehlau & Froelich's variables we found with just a few exceptions. Of the total number of confirmed variables, we found a total of 112 RR Lyrae stars, several of which exhibited the Blazhko Effect. Of the total we classified 55 RR0, 57 RR1, 19 variables with periods greater than 2 days, a W UMa contact binary, and an SX Phe star. We present the periods of previously found variables as well as the periods, classification, and light curves of the newly discovered variables.

Subject headings: stars: variables: general–Galaxy: globular clusters: individual: M14

1. INTRODUCTION

Globular clusters provide a laboratory for studying stellar evolution of a coeval population of stars. This allows for the examination of various evolutionary phases of the stellar population. Of particular interest are post main sequence variable stars in globular clusters. The most common type of variable stars in globular clusters are RR Lyrae stars. These stars are horizontal branch stars that lie within the instability strip. Only low metallicity clusters contain RR Lyrae stars. Having a metallicity of $[\text{Fe}/\text{H}] = -1.39$ the globular cluster M14 is one such cluster (Harris 1996).

M14 (NGC 6402) is a globular cluster with many known variable stars. Clement's Catalogue of Variable Stars in Globular Clusters (Clement et al. 2001) reports 90 possible variables of which 61 have determined periods. 54 of these have been identified as RR Lyraes, 6 as Cepheids or RV Tau, 6 as long term or irregular variables, and no eclipsing binaries or SX Phoenix stars. Most of these were found by Wehlau & Froelich (1994) using photographic photometry on data obtained between 1912 and 1980 mostly by H. S. Hogg (Sawyer-Hogg & Wehlau 1968). Additional unpublished studies have also been conducted which do not appear in Clement's catalogue, and have found several additional variables (Jacobs 2004). M14 lies near the celestial equator so is visible in both the southern and northern hemisphere. Given our extended access to telescopes in each hemisphere, M14 was an ideal candidate to search for variables.

In this study we use an image subtraction method developed by Alard (2000) to search the central $13 \times 13'$ of globular cluster M14 for variable stars from observations obtained in June and July of 2010. With the combination of better resolution CCD images and image subtraction, we can better resolve variables dimmer and/or closer to the crowded field in the core as compared to previous photographic studies. In doing so, we have con-

firmed many of the previously found variables, confirmed or have better determined periods, as well as identified a large number of new variables in the cluster.

2. OBSERVATIONS AND REDUCTION

Image frames were obtained using two different telescopes, one at Kitt Peak National Observatory (KPNO) and the other at Cerro Tololo Interamerican Observatory (CTIO). On the nights of 6, 9, 16, 18 and 19 June 2010, images were obtained using the KPNO SARA (Southeastern Association for Research in Astronomy) 0.9 meter telescope with an Apogee Alta U42 CCD with a 2048×2048 Kodak e2V CC42-40 with a gain of 1.2 electrons per count, RMS noise of 6.3 electrons, and cooled to a temperature of approximately -30 degrees Celsius. 1×1 binning was used, resulting in a scale of $0.42''/\text{px}$ and a $13.6 \times 13.6'$ field of view. Typical seeing was $2.2''$ and ranged from 1.5 - $3.0''$. Using a Bessel R filter, exposure times were set at a constant 60 seconds to avoid overexposure of the core or bright giants during best possible seeing conditions.

Another set of images were taken with the SARA 0.6 meter telescope at CTIO on 3, 4, 5, 9, 13, and 19 July 2010 using an Apogee Alta E6 with a 1024×1024 Kodak KAF1001E chip, with a gain of 1.5 electron per count, and an RMS noise of 8.9 electrons. The temperature was held at -30 Celsius. 1×1 binning was used with a resulting image scale of $0.6''/\text{px}$ and a $10 \times 10'$ field of view. Typical seeing was $1.8''$ and ranged from 1.2 to $2.5''$. Using a Bessel V filter, exposure times were set at a constant 150 seconds to achieve similar images as with the KPNO observations. This also ensured that none of the bright stars were overexposed during periods of good seeing. Maxim DL was used to process the CCD images. Each image was debiased, flat-fielded, and dark-subtracted. These processed images were then analyzed using image subtraction.

The autoguider at KPNO was not functioning properly except on the night of 6 June, and was also not functioning properly for a number of nights but the CTIO telescope tracked much better than the KPNO telescope

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minimizing the importance for autoguiding. Because of this, the CTIO telescope resulted in higher quality images. The KPNO images were only used to examine regions outside of the smaller $10 \times 10'$ field of view of the CTIO telescope.

3. IMAGE SUBTRACTION

Image Subtraction was completed using the ISIS-2.1 package (Alard & Lupton 1998; Alard 2000). The ISIS package consists of six different c-shell scripts: **interp** (registration and interpolation), **ref** (builds reference frame), **subtract** (subtracts images from reference), **detect** (stacks subtracted images), **find** (finds variables above user-defined threshold), and **phot** (makes light curves for found variables), along with three parameter files.

ISIS accounts for changes in seeing conditions by convolving a high quality reference image to the point spread functions of each individual frame and then subtracting the two images to determine if any change in intensity has occurred. These subtracted frames are then combined to create a **var.fits** image which shows the degree of variability across the observation run for each star in the cluster.

The **SIGTHRESH** parameter controls the threshold for which a star is considered a variable. Typical values were for 0.15 for SARA KPNO and 0.05 for SARA CTIO observations, with each producing roughly 270 possible variables. Many of which were due to noise and later eliminated after examining the individual light curves. Values for **SIGTHRESH** were found by looking for the point at which the number of possible objects increased rapidly. A lower **SIGTHRESH** value typically led to a thousand or more false-positives. Once the proper **SIGTHRESH** value was found and false positives eliminated, light curves of relative flux were then generated for each detected variable.

In order to maintain consistent and comparable values for relative flux across nights, one reference image was created using five of the best images from June 6 and this was then used as the reference for all of the KPNO observations. Since the CCD pixel scale is different on the CTIO telescope, a different reference image was used for the CTIO observations. Thirteen of the images with best seeing (average of $1.4''$) were used to create the reference image used for all CTIO observations. The **ref.fits** and **var.fits** images from SARA Cerro Tololo are shown in Figures 1 and 2.

4. ANALYSIS

4.1. Periods

Periods were determined, when possible, based on combined photometric data from the runs on each of the two telescopes. We used the period finding software AVE (Análisis de Variabilidad Estelar, Analysis of Estelar Variability) from Grup d'Estudis Astronòmics. The software uses the Lomb-Scargle algorithm (Scargle 1982). With data over six full nights, we were able to determine periods of nearly all of the variables having periods under 3 days as can be seen in Table 1 & 2. However, a few of these variables had multiple possible periods. The periods were generally accurate to 10^{-4} days. Due to our lack of long term observations spanning several months

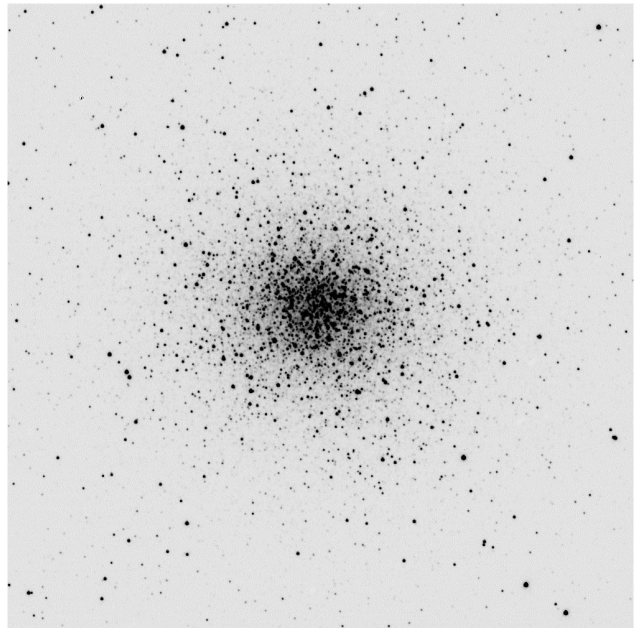


FIG. 1.— The **ref.fits** used for all nights from SARA CTIO. This image is a combination of the best seeing images, with the combined seeing near $1.4''$.

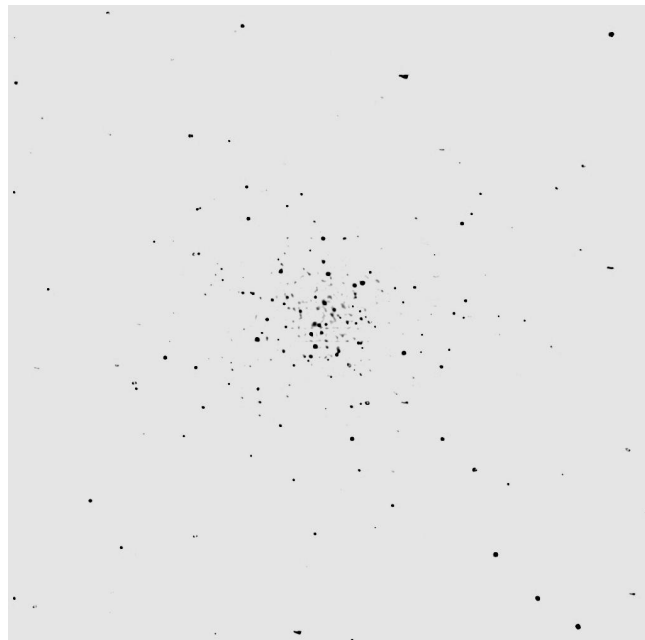


FIG. 2.— The **var.fits** from ISIS for all six nights from SARA CTIO. The relative amount of variation is indicated by the brightness of the star.

or more, we were unable to accurately ascertain the periods of variables greater than a few days. As we obtain more observations, we hope to determine the periods of these variables as well.

Apart from the longer period variables, we verified the periods of nearly all of the Wehlau & Froelich (1994) variables with only a few exceptions where there were multiple periods possible. The only RR Lyrae star that we found a significant period differing from Wehlau & Froelich was 77. We found a period of 0.7910 versus 0.3274 days.

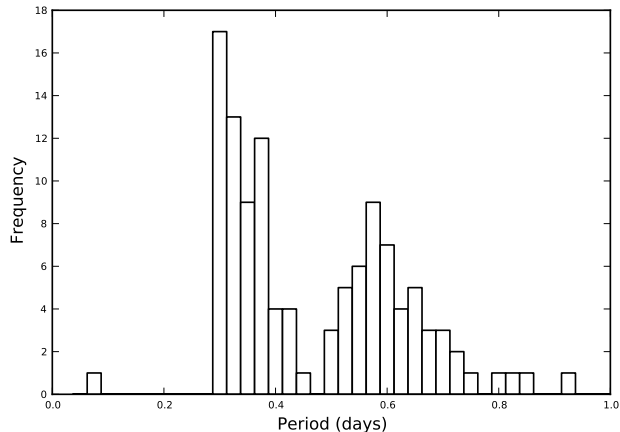


FIG. 3.— A period histogram of observed variables with periods less than 1 day. Note the distinctive break just above 0.4 days. This break separates the RR0 variable stars (right peak) from the RR1 variables (left peak).

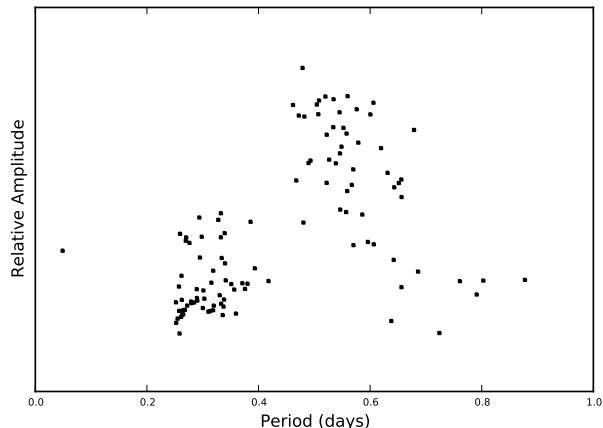


FIG. 4.— A plot of variable period versus amplitude. Similar to figure 3 there is a distinctive separation of the RR0 and RR1 stars.

4.2. Identification

Astrometry was done by finding a plate solution using positions from Clement’s Catalogue of Variable Stars in Globular Clusters (Clement et al. 2001). We then found additional potential variable matches by comparing our coordinates with those in previous publications. Once these were found, they were confirmed through period comparisons. We compared our results with Wehlau and to the unpublished results of Jacobs (2004). Unfortunately the Jacobs astrometry had an error in the right ascension so we could only make a useful comparison to the Wehlau & Froelich variables in the Jacobs’ data set.

In keeping with previously published work, we retained Wehlau & Froelich’s number system for stars 1 through 93. Newly discovered variables from this research are in order of increasing right ascension and begin with variable number 94. Of Wehlau & Froelich’s 93 variables, we were able to find and confirm 63 of them. Many of those variables we could not confirm within our field of view are listed as *blended* or *NV* (meaning not variable) in Clement et al. (2001), and thus their variability is either suspect or difficult to determine. Two others variables

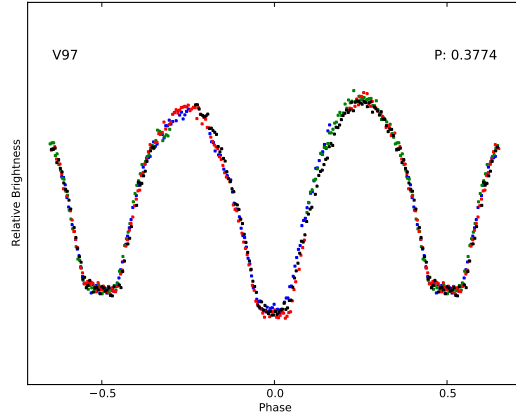


FIG. 5.— Phased light curve of the over-contact eclipsing binary (V97). This binary has a typical W Ursae Majoris light curve.

TABLE 1
CLASSIFICATION SUMMARY

| Variable Type | Count | Period (days) |
|------------------|-------|---------------|
| SX Phoenix | 1 | 0.05 |
| RR0 | 55 | 0.2-0.4 |
| RR1 | 57 | 0.4-0.8 |
| Eclipsing Binary | 1 | 0.3774 |
| Longer Period | 19 | $P > 2$ days |

(V27 and 28) were not observed because they lay outside of our field of view. This left only six remaining variables that we were unable to confirm in the Clement et al. (2001) catalogue (V25, 45, 68, 69, 71 and 86).

4.3. Classification

We classified each variable by considering both the shape of the phased light curve, its amplitude, and its period. The relationship between period and variable type is seen in Figure 3. All but one of the variables shown in this histogram are RR Lyrae variables. The single variable found with a period near 0.05 days is an SX Phoenix star. It is obvious from Figure 3 that there are two distinct types of RR Lyrae stars. Most of our detected variables proved to be RR Lyraes which are then subdivided into the two different types. We used the same notation as Clement et al. (2001) and classified the RR Lyraes as either type RR0 or RR1 for consistency. Besides the obvious difference in periods and appearance of the phased light curves (see Figure 6), the distinction between RR0 and RR1 becomes readily apparent when comparing the amplitude of the magnitude fluctuation to the period of variability as seen in Figure 4. The shorter-period RR1 variables (lower left) generally have less variability compared to the longer-period RR0 variables (right). RR Lyraes with periods ranging from 0.2-0.4 are of the type RR1, and those with periods from 0.4-0.8 are of the type RR0. A summary of the numbers of each type of variable classified is shown in Table 1. The majority of our newly found variables were of the RR1 type. Given that RR1’s have a lower amplitude of pulsation, it is reasonable to

assume that many of these would not have been found in previous photographic studies.

The shortest period of our detected variables (0.049 days) is that of an SX Phoenix star (V161). Because of the short term variability and a longer term trend from night to night, we found it difficult to combined the data over several night so in figure 6 we only show the phased light curve for a single night (with about 6 cycles per night) to eliminate longer term variations.

TABLE 2
VARIABLES FOUND IN M14

| V# | RA (h,m,s) | Dec ($^{\circ}$,',") | Period (d) | Type |
|----|-------------|------------------------|------------|-------|
| 1 | 17 37 37.22 | -3 13 59.4 | ~20 | lp |
| 2 | 17 37 28.39 | -3 16 44.7 | 2.7939 | W Vir |
| 3 | 17 37 35.87 | -3 16 14.8 | 0.5223 | RR0 |
| 4 | 17 37 46.87 | -3 13 32.9 | 0.6514 | RR0 |
| 5 | 17 37 27.02 | -3 13 16.5 | 0.5488 | RR0 |
| 6 | 17 37 38.37 | -3 16 3.0 | >25 | lp |
| 7 | 17 37 40.25 | -3 16 22.0 | 13.361 | lp |
| 8 | 17 37 42.47 | -3 14 10.2 | 0.6860 | RR0 |
| 9 | 17 37 46.21 | -3 15 25.1 | 0.5387 | RR0 |
| 10 | 17 37 32.77 | -3 18 9.9 | 0.5860 | RR0 |
| 11 | 17 37 49.14 | -3 18 28.5 | 0.6044 | RR0 |
| 12 | 17 37 51.11 | -3 17 43.1 | 0.5045 | RR0 |
| 13 | 17 37 34.21 | -3 16 44.2 | 0.5340 | RR0 |
| 14 | 17 37 39.63 | -3 14 48.5 | 0.4722 | RR0 |
| 15 | 17 37 27.14 | -3 12 17.7 | 0.5578 | RR0 |
| 16 | 17 37 30.83 | -3 15 21.3 | 0.6005 | RR0 |
| 17 | 17 37 20.90 | -3 12 42.8 | ~11 | lp |
| 18 | 17 37 40.28 | -3 15 7.7 | 0.4790 | RR0 |
| 19 | 17 37 27.59 | -3 14 43.3 | 0.5460 | RR0 |
| 20 | 17 37 26.40 | -3 13 7.1 | 0.2635 | RR1 |
| 21 | 17 37 40.87 | -3 12 40.3 | 0.3188 | RR1 |
| 22 | 17 37 40.78 | -3 13 11.0 | 0.6564 | RR0 |
| 23 | 17 37 41.31 | -3 16 4.2 | >25 | lp |
| 24 | 17 37 35.97 | -3 13 30.4 | 0.5199 | RR0 |
| 29 | 17 37 31.61 | -3 17 15.9 | >25 | lp |
| 30 | 17 37 41.13 | -3 14 57.7 | 0.5345 | RR0 |
| 31 | 17 37 33.46 | -3 14 13.7 | 0.6196 | RR0 |
| 32 | 17 37 38.42 | -3 12 18.7 | 0.6559 | RR0 |
| 33 | 17 37 26.83 | -3 14 31.1 | 0.4805 | RR0 |
| 34 | 17 37 31.37 | -3 14 18.6 | 0.6066 | RR0 |
| 35 | 17 37 28.42 | -3 15 34.8 | 0.5266 | RR0 |
| 36 | 17 37 50.03 | -3 20 28.4 | 0.6787 | RR0 |
| 37 | 17 37 36.50 | -3 14 27.1 | 0.4897 | RR0 |
| 38 | 17 37 36.81 | -3 15 2.7 | 0.5084 | RR0 |
| 39 | 17 37 39.15 | -3 14 46.1 | 0.5760 | RR0 |
| 41 | 17 37 34.91 | -3 14 47.1 | 0.2594 | RR1 |
| 42 | 17 37 38.52 | -3 14 33.5 | 0.6313 | RR0 |
| 43 | 17 37 40.52 | -3 14 23.4 | 0.5222 | RR0 |
| 44 | 17 37 37.35 | -3 12 47.6 | 0.2894 | RR1 |
| 46 | 17 37 42.12 | -3 15 50.7 | 0.3330 | RR1 |
| 47 | 17 37 30.11 | -3 14 18.1 | 0.8774 | RR0 |
| 48 | 17 37 35.67 | -3 14 4.7 | 0.4677 | RR0 |
| 49 | 17 37 29.66 | -3 15 3.8 | 0.6423 | RR0 |
| 51 | 17 37 43.12 | -3 19 52.2 | 0.2682 | RR1 |
| 55 | 17 37 38.28 | -3 12 58.8 | 0.3374 | RR1 |
| 56 | 17 37 31.63 | -3 17 48.8 | 0.3413 | RR1 |
| 57 | 17 37 45.06 | -3 16 40.9 | 0.5672 | RR0 |
| 58 | 17 37 27.91 | -3 15 18.5 | 0.4179 | RR1 |
| 59 | 17 37 33.97 | -3 14 15.9 | 0.5570 | RR0 |
| 60 | 17 37 38.87 | -3 13 50.6 | 0.5789 | RR0 |
| 61 | 17 37 37.00 | -3 15 28.6 | 0.5698 | RR0 |
| 62 | 17 37 20.68 | -3 17 19.4 | 0.6380 | RR0 |
| 70 | 17 37 38.93 | -3 15 8.1 | 0.6060 | RR0 |
| 73 | 17 37 36.39 | -3 14 38.1 | >25 | lp |
| 74 | 17 37 36.54 | -3 13 14.5 | >25 | lp |
| 75 | 17 37 38.43 | -3 14 55.7 | 0.5453 | RR0 |
| 76 | 17 37 29.05 | -3 14 44.1 | 1.8979 | RR0 |
| 77 | 17 37 28.81 | -3 13 46.5 | 0.7910 | RR0 |
| 78 | 17 37 26.97 | -3 14 47.4 | 0.3102 | RR1 |
| 79 | 17 37 35.35 | -3 15 00.3 | 0.5597 | RR0 |
| 88 | 17 37 30.85 | -3 14 32.4 | 0.3130 | RR1 |
| 90 | 17 37 33.51 | -3 15 16.2 | 0.3512 | RR1 |
| 94 | 17 37 23.04 | -3 14 50.5 | 0.2585 | RR1 |

TABLE 2 — *Continued*

| V# | RA (h,m,s) | Dec ($^{\circ}$,',") | Period (d) | Type |
|-----|-------------|------------------------|------------|--------|
| 95 | 17 37 24.17 | -3 17 28.5 | 0.3596 | RR1 |
| 96 | 17 37 24.72 | -3 14 46.3 | 0.2524 | RR1 |
| 97 | 17 37 25.02 | -3 18 36.5 | 0.3774 | EB |
| 98 | 17 37 25.81 | -3 12 47.8 | 0.2579 | RR1 |
| 99 | 17 37 26.58 | -3 14 46.1 | ~15 | lp |
| 100 | 17 37 29.72 | -3 15 20.5 | 0.2612 | RR1 |
| 101 | 17 37 30.28 | -3 15 52.7 | >25 | lp |
| 102 | 17 37 31.38 | -3 16 0.6 | ~15 | lp |
| 103 | 17 37 32.48 | -3 14 12.5 | >25 | lp |
| 104 | 17 37 32.69 | -3 14 56.0 | 0.2620 | RR1 |
| 105 | 17 37 32.95 | -3 14 3.3 | 0.2793 | RR1 |
| 106 | 17 37 33.28 | -3 14 46.4 | 0.5465 | RR0 |
| 107 | 17 37 33.56 | -3 14 48.2 | 0.2950 | RR1 |
| 108 | 17 37 33.62 | -3 15 12.0 | 0.3565 | RR1 |
| 109 | 17 37 33.64 | -3 14 40.9 | 0.6562 | RR0 |
| 110 | 17 37 33.64 | -3 16 10.2 | 0.3013 | RR1 |
| 111 | 17 37 33.71 | -3 15 11.9 | 0.2791 | RR1 |
| 112 | 17 37 33.76 | -3 17 14.7 | 0.3156 | RR1 |
| 113 | 17 37 33.91 | -3 14 27.5 | 0.2574 | RR1 |
| 114 | 17 37 33.91 | -3 14 52.5 | 0.3325 | RR1 |
| 115 | 17 37 33.95 | -3 14 24.1 | 0.3359 | RR1 |
| 116 | 17 37 34.03 | -3 15 37.7 | 0.2521 | RR1 |
| 117 | 17 37 34.10 | -3 14 35.9 | 0.3394 | RR1 |
| 118 | 17 37 34.24 | -3 16 13.0 | 0.3803 | RR1 |
| 119 | 17 37 34.45 | -3 14 52.1 | 0.3341 | RR1 |
| 120 | 17 37 34.65 | -3 13 29.6 | 0.3279 | RR1 |
| 121 | 17 37 35.04 | -3 15 19.7 | 0.2704 | RR1 |
| 122 | 17 37 35.30 | -3 14 39.2 | 0.5590 | RR0 |
| 123 | 17 37 35.55 | -3 15 44.1 | 0.2846 | RR1 |
| 124 | 17 37 35.75 | -3 15 27.3 | 0.2762 | RR0 |
| 125 | 17 37 35.79 | -3 15 15.1 | ~20 | lp |
| 126 | 17 37 35.83 | -3 14 53.7 | 0.2939 | RR1 |
| 127 | 17 37 35.92 | -3 14 32.8 | 0.2983 | RR1 |
| 128 | 17 37 35.95 | -3 13 52.8 | 0.3935 | RR1 |
| 129 | 17 37 36.11 | -3 15 1.4 | 0.2796 | RR1 |
| 130 | 17 37 36.26 | -3 15 25.4 | 0.5961 | RR0 |
| 131 | 17 37 36.27 | -3 14 54.3 | 0.2697 | RR1 |
| 132 | 17 37 36.53 | -3 15 14.7 | 0.4822 | RR0 |
| 133 | 17 37 36.64 | -3 18 15.9 | 0.3030 | RR1 |
| 134 | 17 37 36.69 | -3 15 5.8 | 0.5072 | RR0 |
| 135 | 17 37 36.82 | -3 13 41.9 | 0.3382 | RR1 |
| 136 | 17 37 36.83 | -3 15 24.5 | 0.3305 | RR1 |
| 137 | 17 37 37.48 | -3 14 40.7 | 0.2763 | RR1 |
| 138 | 17 37 37.93 | -3 15 33.0 | 0.3710 | RR1 |
| 139 | 17 37 37.99 | -3 17 23.7 | 0.2722 | RR1 |
| 140 | 17 37 38.21 | -3 15 51.9 | 0.7609 | RR0 |
| 141 | 17 37 38.31 | -3 14 27.2 | 0.6433 | RR0 |
| 142 | 17 37 38.72 | -3 14 2.1 | 0.4618 | RR0 |
| 143 | 17 37 38.82 | -3 16 31.2 | 0.3185 | RR1 |
| 144 | 17 37 39.27 | -3 14 29.7 | 0.3758 | RR1 |
| 145 | 17 37 39.97 | -3 15 1.4 | 0.3003 | RR1 |
| 146 | 17 37 40.16 | -3 16 8.6 | >25 | lp |
| 147 | 17 37 40.22 | -3 15 55.5 | 0.4932 | RR0 |
| 148 | 17 37 40.73 | -3 17 0.3 | 0.2651 | RR1 |
| 149 | 17 37 41.07 | -3 10 4.7 | 0.5523 | RR0 |
| 150 | 17 37 41.14 | -3 14 8.0 | 0.8028 | RR0 |
| 151 | 17 37 41.19 | -3 14 22.7 | 0.3198 | RR1 |
| 152 | 17 37 41.90 | -3 15 37.1 | >25 | lp |
| 153 | 17 37 41.98 | -3 11 56.0 | 0.2650 | RR1 |
| 154 | 17 37 42.54 | -3 13 59.4 | 0.2551 | RR1 |
| 155 | 17 37 42.93 | -3 14 5.3 | ~15 | lp |
| 156 | 17 37 43.60 | -3 14 24.6 | >25 | lp |
| 157 | 17 37 43.79 | -3 16 13.4 | 0.2626 | RR1 |
| 158 | 17 37 43.88 | -3 13 0.7 | 0.7242 | RR0 |
| 159 | 17 37 43.99 | -3 13 44.8 | 0.2897 | RR1 |
| 160 | 17 37 44.24 | -3 15 34.8 | 0.3400 | RR1 |
| 161 | 17 37 44.52 | -3 11 51.5 | 0.0490 | SX Phe |
| 162 | 17 37 49.69 | -3 11 49.2 | ~20 | lp |
| 163 | 17 37 53.71 | -3 14 18.8 | 0.2903 | RR1 |
| 164 | 17 37 56.28 | -3 10 16.3 | 0.3326 | RR1 |

We assign 'lp' to any variable with a period greater than 3 days.

Several of the RR0 variables showed evidence of the Blazhko effect (Blazhko 1907; Smith 2004) resulting in long term modulation in the amplitude. Although our

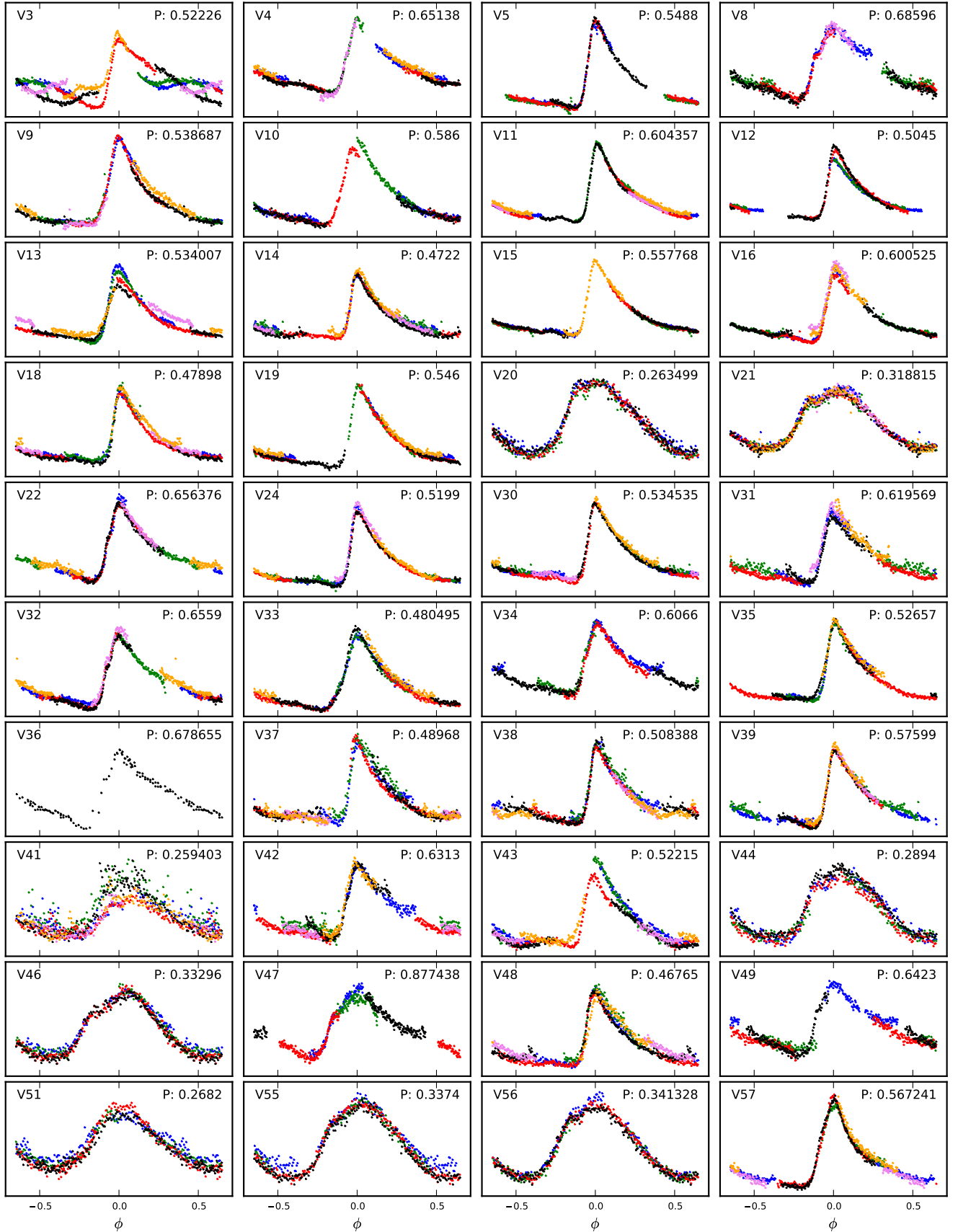


FIG. 6.— Phased light curves for all detected variables with periods under 3 days. The vast majority of these variables are RR Lyrae stars.

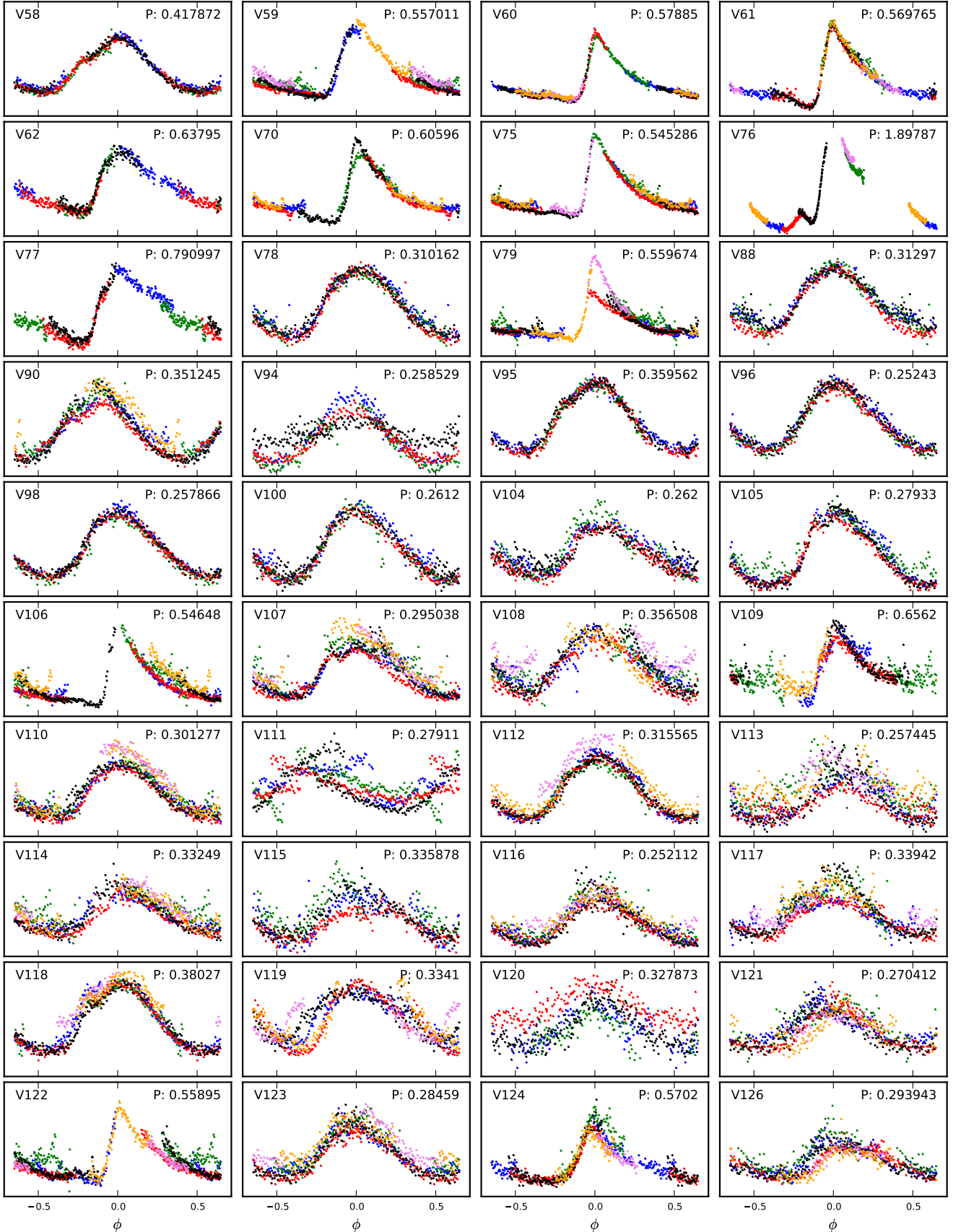


FIG. 6.— (Continued) Phased light curves for all detected variables with periods under 3 days. The vast majority of these variables are RR Lyrae stars.

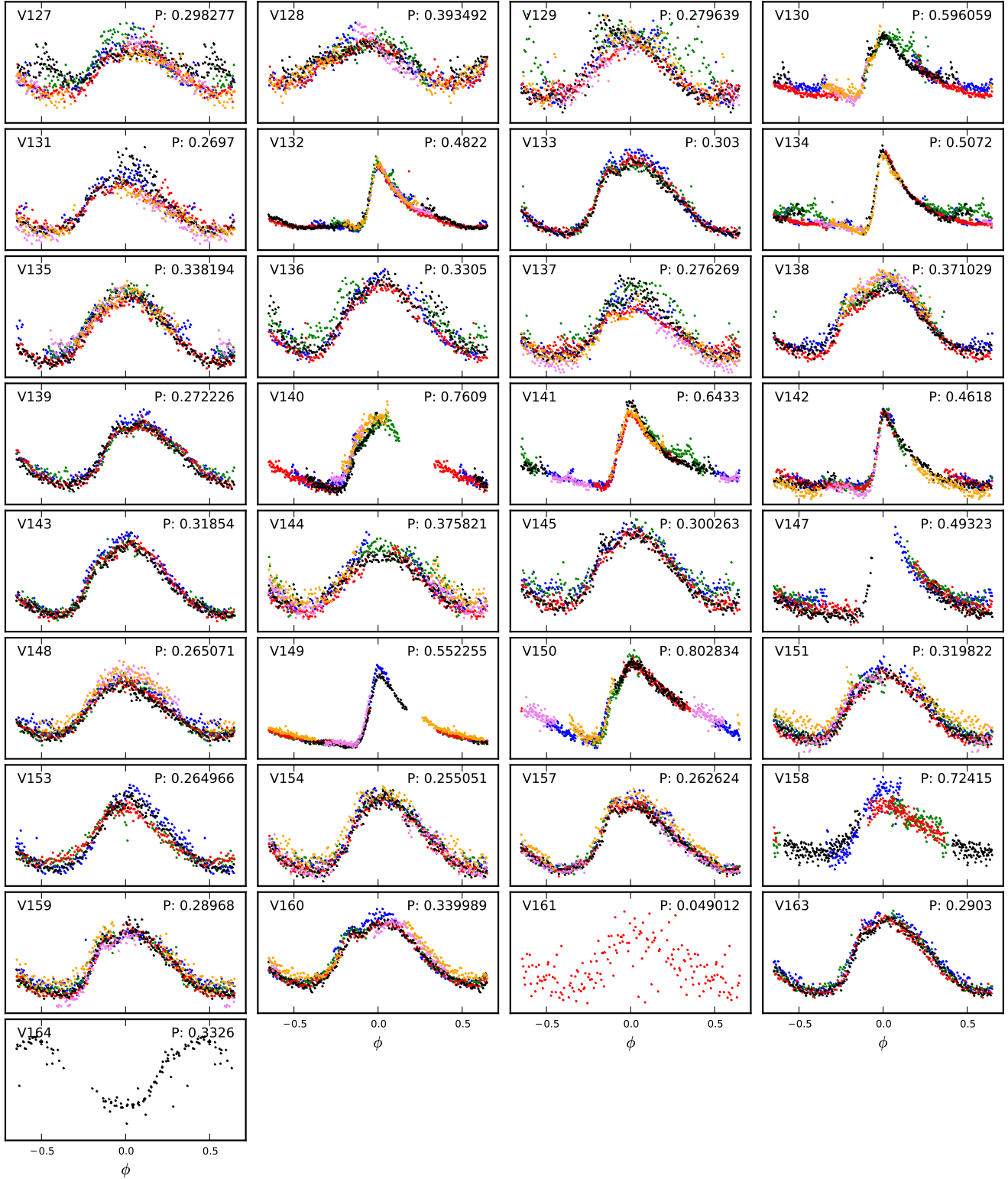


FIG. 6.— (Continued) Phased light curves for all detected variables with periods under 3 days. The vast majority of these variables are RR Lyrae stars.

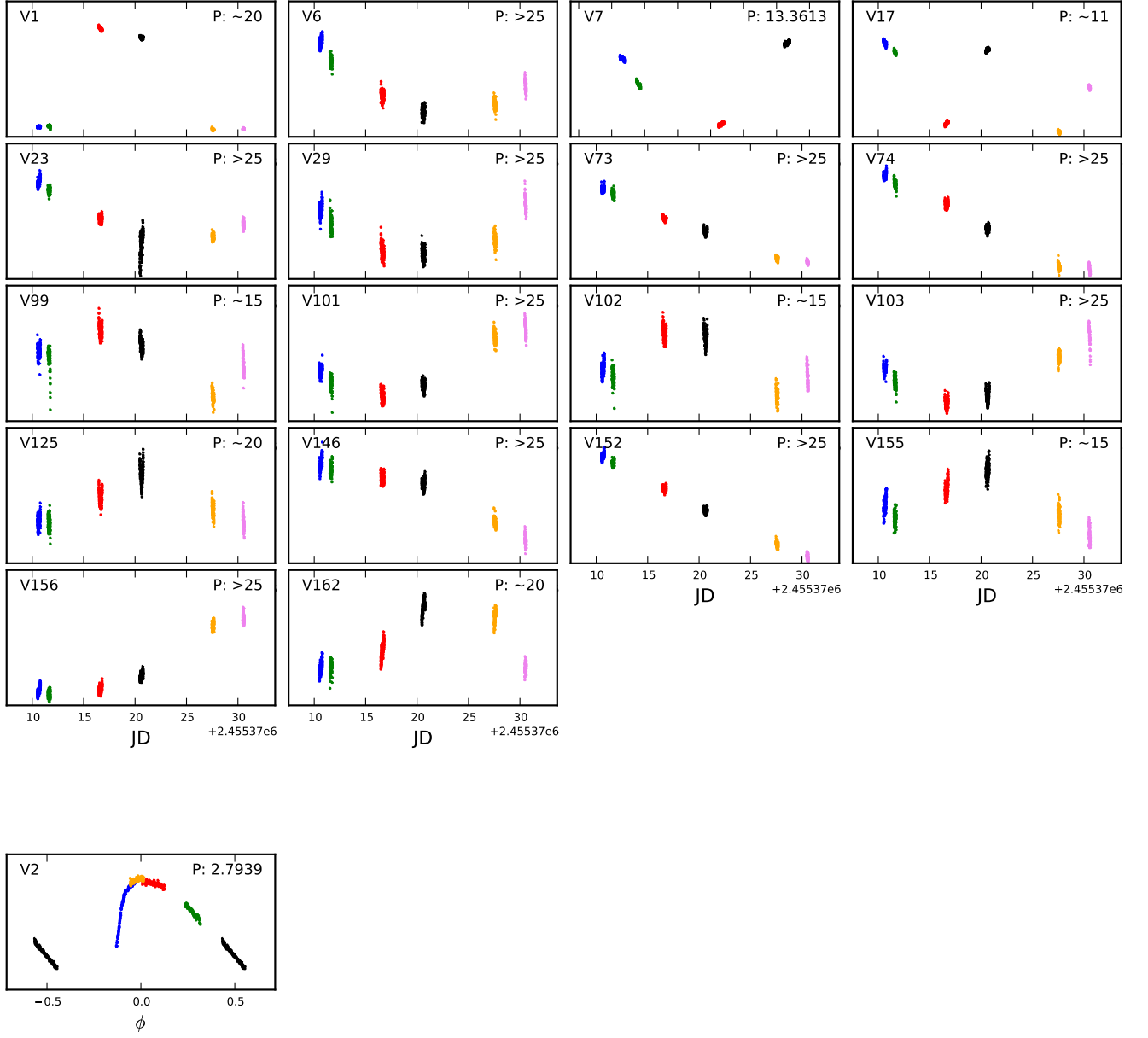


FIG. 7.— Light curves for all detected variables with periods over 2 days.

observations were not long enough to find this secondary period, the effect is apparent in V3, V13, V31, V43, V70, and V79 (Figure 6).

Among the new variables we detected was an eclipsing binary shown in Figure 5, V97. The shape of the light curve indicates it is a W UMa contact binary. The distortion between and similar depths of the eclipses suggest an over-contact binary, while the relative flatness of eclipses suggest a large mass ratio (Rucinski 1992; Webbink 2003).

By running all of our Cerro Tololo data through ISIS simultaneously we were able to detect several possible long term variables. Many of these are most likely red giant stars undergoing longer term pulsations. All of our potential longer period variables are included in Table 2 listed as 'lp' and their light curves are plotted unphased in Figure 7. Our observing time span was not long enough to observe multiple cycles for these variables. Those with periods listed are only estimates.

All detected variables and their periods and classification are shown in Table 2. Light curves of variables with shorter periods are shown phased in Figure 6, whereas the light curves of longer period variables are shown unphased except for V2 in Figure 7. V2 is an W Vir star with a period of 2.7939 days. Given its relatively short period, we show its light curve as phased.

5. CONCLUSIONS

We observed the globular star cluster M14 for 12 nights over a 40 day period using the SARA telescopes located at KPNO and CTIO. We used the image subtraction method of Alard (2000) to search for variable stars in M14. We confirmed 63 previously known variables catalogued by Wehlau & Froelich (1994). In addition to the previously known variables we have identified 71 new variables. Of the variables we were able to detect we have confirmed the periods the Wehlau and Froelich RR Lyrae stars with one exception. Of the total number of confirmed variables we found 55 RR0, 57 RR1, 19 variables with periods greater than 2 days, a W UMa contact binary, and an SX Phoenix star. We confirmed the periods of previously found variables as well as the determined of the periods, classification, and light curves of the newly discovered variables.

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